THEME: INTERNATIONAL INNOVATION

Full Paper

IMPLEMENTING INNOVATION ON COMMERCIAL BUILDING PROJECTS IN AUSTRALIA

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ABSTRACT

Since the 1950s, economic theory has highlighted the 'central importance of technological progress for maintaining long-term, continuous increases in real national income per head' (Hall 2003, 498). Empirical work since that time has reinforced the importance of innovation to industry growth and national economic welfare. Hence, innovation can be considered a key means of improving construction industry performance. Yet, a recent study of efficiency improvement in construction reminds us that the industry has yet to embrace the value of innovation (Yiu et al 2004). That this is particularly so in the Australian context is evidenced by the findings of the recent Cole Royal Commission (2002b).

The industry in Australia and globally is slow to embrace change and there are powerful cultural reasons why this is so. The reason addressed by this paper is concern by industry participants about the risks associated with innovation and lack of information about appropriate implementation strategies. In order to improve this situation the key players and dynamics behind successful implementation of innovation are explored here.

The paper is based on three innovation case studies in the Australian commercial building industry undertaken in 2003. Each case involves innovation undertaken on a commercial building project by clients, contractors, consultants and/or suppliers.

The paper reviews the industry's performance in Australia, before outlining the methodology and conceptual framework. Data from the case studies is then described and analysed. The evidence presented points to four key participants driving innovation processes; clients, regulators, technical service providers and consultants.

Keywords: innovation processes, client-driven innovation, regulators, technical support providers, consultants, Australian commercial building industry

INTRODUCTION

This paper addresses the research question 'who are the key players in implementing innovation on Australian commercial building projects and what roles do they play?' The aim of this paper is to demonstrate the nature of successful innovation implementation processes in this context. The paper makes an original contribution to the literature by examining the roles of project participants in project-based innovation, in the Australian commercial building context. The need for the study arose from widespread evidence of poor performance in the sector in Australia and globally (Gyles 1992, Egan 1998, Cole 2002a), and local evidence suggesting that many industry participants, particularly SMEs, were unsure about how to go about implementing innovation (Manley and Blayse 2003). This evidence about innovation is concerning, given the established links between innovation and economic growth (OECD 2000). This relationship exists regardless of whether the innovation is an original development, or whether it involves the adoption of best practice, which already exists, but is new to the adopting firm.

Historically, there have been few incentives for the construction industry to undertake innovation, due to the absence of strong competitive forces (Seaden 1996, 1). However, since the 1990s the industry has been under increasing pressure to improve efficiency and effectiveness. The drivers of industry improvement that emerged last decade still apply pressure today. These include the emergence of more demanding clients as public sector resources decline; the challenges of increasingly global competition; and the demands of strict environmental legislation (Seaden 1996, 3). In Australia, as in other developed countries (particularly the UK), significant government programs have been introduced to remove the obstacles to industry growth. Since the Gyles Royal Commission in 1992, considerable attention has been paid to improving the industry's performance. This culminated in a partnership between the Commonwealth Government and the industry to develop an Action Agenda, with government funding of $3.6 million devoted to a comprehensive suite of initiatives to promote industry growth. These activities ran between 1999 and 2002 and an evaluation of the program in 2004 found that innovation performance had improved, but that better outcomes were possible given a better demonstration and diffusion effort (DISR 2004, 2-3). The current paper responds to the opportunity to further improve innovation outcomes revealed by the evaluation.

Despite the contributions of a range of authors on the broad topic of innovation success factors (eg. van der Panne et al 2003, Gann 2001, Winch 1998), there remained an opportunity to extend the literature by exploring different types of participants as innovation implementation drivers on Australian commercial building projects.

Perhaps the most relevant academic work to the current study is Ling (2003), Slaughter (2000) and Gann and Salter (1998). Ling's (2003) study is a quantitative study of the factors that support innovation benefits. The case study work undertaken here helps to flesh out her results and provides a different focus by examining the roles of particular types of project participants.

Slaughter (2000) conceptualises the implementation stages for construction innovation, as a component of a business's innovation strategy. The current study adopts a broader approach by looking beyond intra-firm processes to examine innovation as the result of inter-organisational relationships. This builds on recognition of the collective nature of innovation process generally (Manley 2003) and the project-based nature of production in the building industry (Gann and Salter 1998). Gann and Salter (1998) provide a useful framework for mapping participants and dynamics as part of an innovation system, which forms the conceptual background for the present study.

METHODOLOGY

A case program was adopted to determine the types of participants in the industry who were most active in driving effective implementation of Australian commercial building innovations. The resources available to the program dictated that three case studies in this sector could be undertaken over nine months, between April and December 2003.

The case studies were nominated by industry partners associated with the research. The industry partners comprised key repeat clients and key consultants. The case studies they nominated were considered best-practice examples of innovation. Only examples with measured benefits from innovation were eligible for inclusion in the program. The innovation examples showing the greatest benefit to a construction project were selected for study. The examples covered innovation arising from the contractor, consultant, client and supplier sub-sectors.

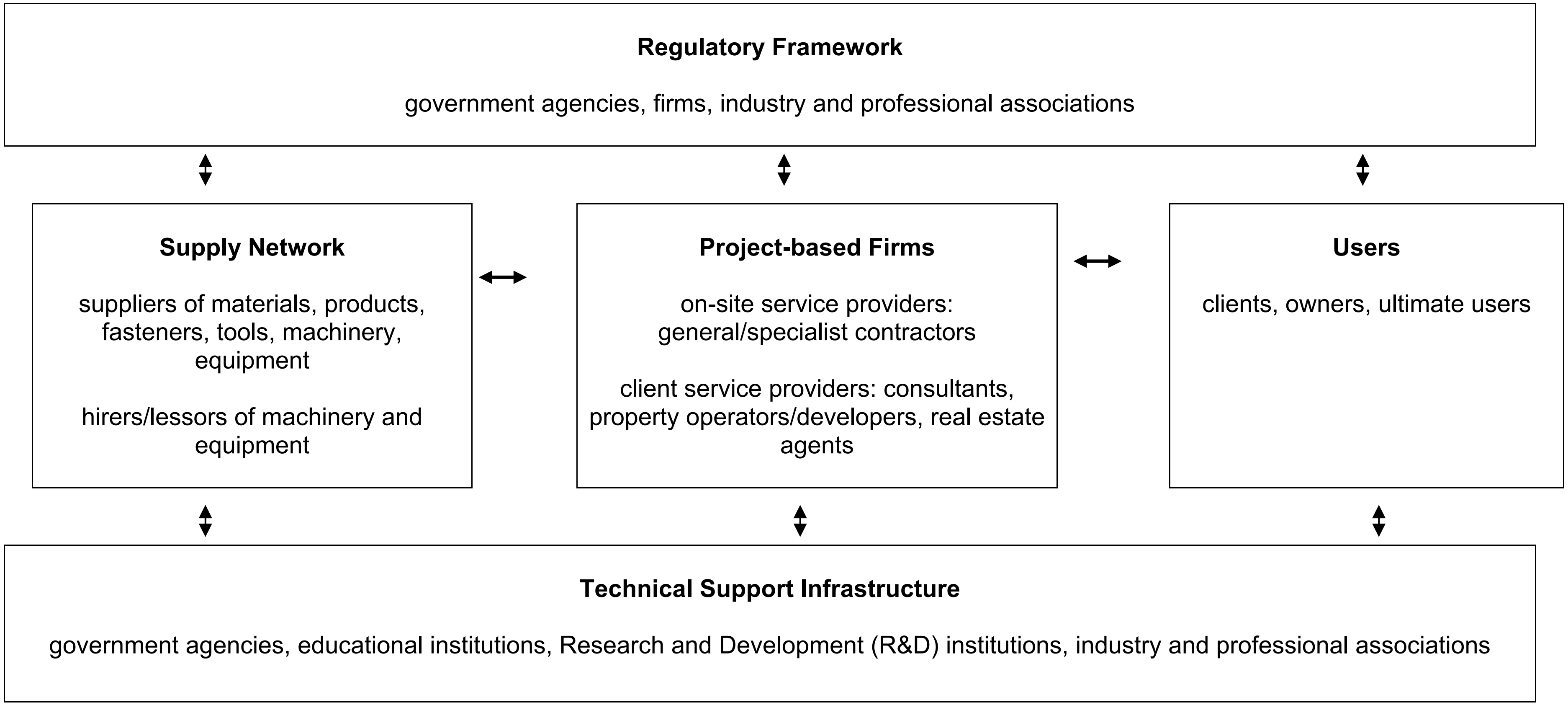
The program reviewed innovative projects in Queensland, New South Wales and Victoria. The focus on building and construction (B&C) projects arises because most readily identifiable innovation takes place there, rather than within particular organisations. The focus on the three states was driven by the fact that they account for 80 per cent of Australia's B&C activity (Cole Royal Commission 2002b, 16).

The case studies were based on semi-structured interviews, and background documentation including award submissions, academic papers, magazine articles, internal reports and workshop presentations. Each case involved multiple interviews covering at least two of the organisations on the project. Each interviewee was a senior technical or management representative and the range of interviewees covered all types of industry participants including clients, contractors, consultants and suppliers.

CONCEPTUAL FRAMEWORK

The case studies were interpreted according to the influential work of Gann and Salter (1998). These authors emphasise the non-linear and highly interactive nature of innovation processes, taking a broad view of the boundaries of the B&C industry. Figure 1 is based on their approach:

Figure 1 The Context for Innovation: Participants and Relationships in the Building and Construction Industry



(Based on Gann and Salter 1998)

Figure 1 provides a good summary of the relevant participants in the B&C industry. It helped in structuring the case studies and positioning key relationships, and provided a useful analytical tool to assist in thinking about the audience(s) for the results of the study, as part of the research dissemination process.

The diagram shows five key classes of participants: project-based firms, suppliers, users, regulators and technical support providers. Sub-classifications are also shown. Relationships between the participants are multi-directional. There is no starting point in the innovation process, as it is not linear. Innovation may be championed or implemented by any of the participants. The empirical work undertaken by the present study aims to further define the roles these participants play in innovation on Australian commercial building projects.

Figure 1 guided qualitative analysis of the case studies. This analysis identified four key innovation participants and their roles in influencing implementation processes. Prior to discussing these findings, the innovation implementation processes are examined.

CASE STUDIES OF INNOVATION IMPLEMENTATION PROCESSES[1]

This section describes three case studies of innovation on projects in the Australian commercial building sector, focussing on implementation processes and the way in which obstacles were overcome. The next section interprets the findings according to the conceptual background of the study and summarises the key learnings from the exercise.

WILLIAM MCCORMACK PLACE: CASE A

William McCormack Place is a 4,568m^2 (net lettable area) four-storey commercial office building in Cairns, Australia. It was built for a public sector client by a private sector construction manager under a two-stage, design and construct, guaranteed maximum price contract with an overall budget of $A17.5 million including fit-out and public art. The building was opened in September 2002, delivered on time and within budget, after an 18-month design and construction program.

The innovation profiled on this project involved a suite of advanced air-conditioning components, including the use of a chilled water thermal tank and a total enthalpy thermal wheel. The thermal tank eliminated the need for a low-load chiller and the associated prolonged periods of inefficient low-load operation of the chiller sets. The moisture-absorbing thermal wheel was used to recover cool and dehumidified outside spill air energy to precondition incoming hot, moist ventilation air. Both these advanced technologies have been employed to a limited extent in Australia and overseas, and their rate of uptake is expected to rapidly increase as the benefits they can deliver become more established.

The Implementation Process

[1] Readers requiring more detail about the case studies are referred to Manley and Blayse (2003). This report provides greater detail about the technology and discusses the benefits they delivered.

A key driver for adoption of the thermal tank and wheel was the client's desire to improve the energy efficiency of its buildings, while the mechanical and electrical consultant was motivated by the potential improvement to its reputation and the belief that this would enhance its competitive position in the marketplace. Both were strongly motivated by the opportunity to enable the building to win the first 5-star energy rating, awarded under the Australian Greenhouse Rating Scheme, for a commercial office building. This aim was achieved.

Thermal Tank

The client's original brief suggested that three chiller sets be installed to manage air-conditioning requirements. However, the consultant advised that it would be more efficient to replace the third low-load chiller with a thermal tank to get maximum efficiency from the chillers. The consultant designed the first large-scale tank in Australia in the late 1990s, roughly a decade after the first use of tanks overseas, and was motivated to do so after having monitored their performance through industry association newsletters and international networks involving R&D conducted by the university sector.

The consultant understood the technology and had proved its effectiveness and the accuracy of payback periods. The client's audit engineers reviewed the design and agreed that energy performance was likely to be significantly improved by the thermal tank. The adoption decision took into account the climatic conditions of the building. The heat and humidity in Cairns is quite extreme, demanding the use of innovative technologies to minimise environmental impacts.

Thermal Wheel

The consultant introduced the first total enthalpy thermal wheel into Queensland in 1986 and has since designed several hundred. They were early adopters of this technology, as such wheels only emerged globally in the mid 1980s.

The company's ability to encourage clients to use the wheels was assisted by its review of developments overseas. Its knowledge and experience enabled it to strongly champion the use of a thermal wheel on the William McCormack Place project, and the client was able to confirm the value of the technology with internal mechanical engineers who knew the wheels were widely used in Europe.

The Queensland Government had an interest in local employment for this regional project through its Local Industry Participation Policy, which provided the consultant with the opportunity to be involved. The consultant was a local firm with considerable expertise, and experience with the often extreme local weather conditions, whilst also having linkages with technical experts in Australia, America and Europe. The success of this project shows that regional firms can be technology leaders and that knowledge can be gained *from* them, rather than merely imparted *to* them.

Overcoming Obstacles

Obstacles to the adoption of environmentally friendly technologies, such as the thermal tank and wheel, have traditionally been high up-front costs and risk aversion. However, this case has shown that:

- the cost element is circumventable when addressed in the overall design and construction of a building; and
- clear objectives and design can reduce the risks for both managing contractors and clients to acceptable levels.

Another problem has been that building users are unaware of the negative environmental impacts of conservative approaches to building. However, as concerns about energy and other conservation issues become more prominent, building users are demanding energy-minimising buildings and creating the need for appropriate project delivery mechanisms. William McCormack Place illustrates the positive impacts of this trend.

The client's traditional method for delivering new office buildings was for a specialist unit to manage the design and construction of a building and then hand it over to the property management area on completion. There were few drivers within this system to maximise building performance, particularly in terms of user-needs and whole-of-life costs. In the case of William McCormack Place, senior management decided that the team responsible for the ongoing management of the building would deliver the project.

This meant that project decisions could be made on the basis of time, budget and quality, and also on the functionality and manageability of the property, based on the building life cycle from a *facility management perspective*. This was the first time the client had managed a major contract in this way, with the facility manager playing such a significant role. The client's role as an informed buyer was enhanced, with the required awareness to encourage the adoption of advanced technologies.

The adoption of advanced technologies was also facilitated by the construction management style of contract, which involved the builder very early in the design process. There were no 'rude shocks' when the advanced technologies were incorporated into the design. The guaranteed maximum price element of the contract ensured that the design was as thorough as possible, to reduce the builders' risk, and to ensure that the final design was 'buildable'.

Finally, there are often obstacles to adoption of advanced technologies and practices when tender selection is based solely on cost, as innovation is rarely associated with the lowest cost tender. In this case, the mechanical and electrical consultant was selected on experience and ability, not just on competitive cost. This approach was critical to adoption of the thermal tank and wheel.

SUNCORP STADIUM: CASE B

Suncorp Stadium is a 52,500-seat, world-class football facility, constructed by a private sector managing contractor under a two-stage, document and construct, guaranteed maximum price contract, with a project budget of $A280 million. The stadium was opened in June 2003, delivered on time and within budget, after a two-year documentation and construction program.

The innovation examined by the study was a new method of manufacturing concrete planks and connecting them to supporting steel beams. Formed rebates were designed for the ends of the pre-cast pre-stressed polystyrene-voided concrete planks.

Complementary design of concrete topping and reinforcement details ensured a crack-free, reliable composite connection between the steel beams that support the grandstands.

Polystyrene-voided planks and formed rebate details had only been combined on a few occasions globally in the building industry. The particular planks and the particular rebate, and associated details, were unique to the Stadium project.

The Implementation Process

The 'clever plank' innovation arose in part from the opportunities for designer and contractor interaction inherent in a document and construct contract. The engineering consultant noted that:

> … the contractual arrangement was not like a lump sum fully documented contract, where the contractor is basically given the design and told to go away and build it. Here, the Joint Venture was encouraged to look at alternative forms of construction

The preliminary stadium design on which the managing contract was tendered incorporated a structural system assessed as the lowest cost option by quantity surveyors, that is, conventionally formed concrete beams and slabs. When the Joint Venture was appointed, the joint venturers agreed that the conventional approach was the cheapest in direct costs; however, they pursued the idea of a steel beam and plank design, based on advantages related to time, risk and management of sub-contractors. The Joint Venture asked the consultants to explore the technical feasibility of such an approach. The consultants found that, while the components were more expensive for beam and plank construction, the timber and sub-contractor savings related to the absence of formwork more than offset the extra expense.

Formwork is very material and labour intensive. The advantages of not requiring formwork for the stadium included:

- a less congested site without large numbers of form workers;
- reduced car parking and concrete truck access problems in the inner city location;
- no concreter delays/disputes to hold up following trade work (previous experience with highly unionised workforces and industrial action fed into the decision-making process);
- no obstruction of the areas underneath the grandstand with temporary propping, which restricts trade work;
- lower safety risk because there is no need for scaffolding, planks and ply; and
- easier quality control and guaranteed standards when concrete planks are manufactured off-site.

The above advantages result for either extruded or voided planks employed in a conventional non-composite way, although voided planks can be more efficiently attached to supporting beams by adjusting the pattern of voids to create solid ends for more robust fixing. The consultant looked beyond these advantages in response to the contractor's request to find further savings.

The contractor's interest in savings was driven by the form of contract. The contract allowed for the development of alternative designs and for shared benefits between the contractor and client if the project was delivered below the guaranteed maximum price. It seems this contractual driver helped to create an environment where innovative ideas were explored and embraced.

The consultant's study of a series of steel and precast plank options found that there were potential cost savings with lighter steel beams, if a reliable and practical method of achieving composite connections between planks and beams could be developed. After consulting with leading international researchers in the field of composite steel connections, it devised the innovative rebate design. It then calculated the theoretical capacity by extrapolating from available theory and codes, and arranged for full-scale prototype testing to verify the accuracy of the design calculations and the efficiency of the connections. The construction program dictated that the manufacture of the clever planks commenced before the prototype testing was completed, but the designers were confident that the results would be positive. Their confidence in the design has subsequently been borne out by the prototype test results and the faultless performance of the planks and concrete topping on site.

The implementation of the clever plank innovation will not end with this project; both the consultant and the supplier intend to use the innovation on future projects. The consultant will maximise these opportunities by publicising clever planks on its internal skills network, which is a formalised knowledge-sharing system operating across the organisation's global operations. The company also plans to submit a paper for publication with the Institution of Engineers, Australia and is currently providing advice to colleagues considering similar plank and beam approaches. Further, the clever plank innovation has been submitted to the consultant's innovation competition, which feeds into the organisation's marketing efforts. Such initiatives encourage employees to take the time to write up the benefits of their innovations, an activity that can otherwise be marginalised in the project-to-project rush of work.

Overcoming Difficulties

A large part of a consultant's role is to provide ideas to clients and contractors, which benefit these two parties, but not necessarily the consultant in a direct sense. Certainly, reputation is important for consultants, especially reputation for money-saving innovations, and the consultant on the project profited in this sense. Nevertheless, the benefits from construction innovation are not evenly spread along the supply chain, nor does the proponent/inventor necessarily profit directly. This problematic incentive structure is likely to constrain innovation efforts.

In the clever planks case, the consultant was aware of recent changes under the Queensland government's prequalification system for building industry consultants, which have seen 'innovation history' added as a criterion. Such moves help to make the benefits of innovation to a company's reputation more tangible, by recording and valuing the extent of the organisation's innovation activity.

Overall, there were few obstacles to the implementation of clever planks on the Stadium project, due to the positive drivers established by the form of contract, which encouraged the contractor to seek and support money-saving innovations.

AUSTRALIAN ART BUILDING: CASE C

The NGV (National Gallery Victoria)-Australian Art Building is a centrepiece of the Federation Square development in Melbourne. Federation Square is one of Australia's civic and cultural icons, incorporating multi-media, art, museum and office buildings. The NGV-Australian Art building was constructed by a private sector managing contractor and was completed in 2002 for approximately $A65 million.

The innovation on the NGV-Australian Art Building examined by this study has three main elements: use of the performance-based Building Code of Australia (BCA); use of Quantitative Risk Assessment (QRA); and use of unprotected steel while meeting fire safety requirements.

The Implementation Process

The key to the benefits achieved by the use of unprotected steel was the QRA, which, in turn, was made possible by the recently implemented performance-based BCA. The managing contractor drove the design shift from concrete to steel, based on its experience of the benefits of steel. The design team drove the use of *unprotected* steel, reaping time and cost benefits, principally by employing QRA.

Risk assessment techniques, such as QRA, are used to evaluate the frequency and probability of threatening events such as fires. Once risks are assessed, options to reduce the risks can be examined and costed, and the most effective option adopted.

There are a number of approaches to risk assessment for fire safety decision-making. One of the most complex of these approaches is QRA, which is based on fault and event scenarios. Fault scenarios can be used to identify mechanisms of failure leading to fire starts. Event scenarios can then identify the probability of the fire advancing from ignition to the various stages of fire development and define the levels of threat to occupants and property. In Australia, this approach is known as an Evaluation Extent 3 or System Risk Evaluation approach, as defined in the Australian Building Codes Board Fire Safety Engineering Guidelines.

In the case of the NGV-Australian Art Building, the concept of five states of fire growth was used to assess the probability and consequences of various times-to-activation of the fire safety systems and human intervention. Further, a number of events and factors were incorporated into the analysis and the associated probabilities enumerated in order to determine the overall probability of fire development and damage to property. These three features – the five fire states; the application of QRA to property; and the method of probabilistic analysis – are cutting-edge. They have been used only rarely globally, and were adopted by the fire engineers on the project through their linkages with international experts, such as engineers conducting R&D with the National Research Council of Canada.

Overcoming Difficulties

One of the primary challenges in the adoption of the fire engineering/unprotected steel innovation was addressing the safety concerns of a number of stakeholders, including the client, about the new approach. One of the key reasons for concern, particularly for the client, was that the QRA approach to fire safety engineering is an analytical process, as opposed to a physical testing-based approach. Acceptance of the QRA results requires an understanding of its theoretical underpinnings, and of the logic that leads to the outcomes. These can be more difficult to communicate than results based on physical testing of materials. However, members of the design team were able to effectively use fire engineering tools, and a cooperative approach, to educate the stakeholders about the relative risks and allay their fears.

QRA is a significant departure from *prescriptive, rule-based* approaches to building construction, and this may also have been a reason for concern. Despite the capacity of QRA to arrive at what are, in many cases, safer and less expensive construction methods, there is still a residual tendency for many stakeholders to prefer uncomplicated rules prescribing conventional building materials and methods. Indeed, QRA is harder to understand than prescriptive rules and this can result in risk-averse responses to its adoption. However, as this case demonstrates, it is possible to reduce this problem using education and a cooperative approach.

DISCUSSION AND CONCLUSIONS

The cases highlight the active role taken by four key types of industry participants in promoting innovation on projects: clients, regulators, technical support providers and consultants. To some extent, these are the likely suspects, although such a list, if it were comprehensive, would also include suppliers. Indeed, suppliers are shown to be significant in research related to that described here (Manley and Blayse 2003).

The literature highlights the importance of the four types of participants emphasised here: clients, regulators, technical support providers and consultants (Briscoe et al 2004, Gann 1998, Nelson 2004, Hislop 2002, Salter and Torbett 2003). This paper adds value to that existing knowledge by investigating in detail the roles of these participants in the implementation phase of innovation on commercial building projects in Australia.

From Case A, it has been shown that informed clients can facilitate the adoption of advanced technologies and practices by expertly cross-checking innovative proposals. For public sector agencies, this creates a driver for retaining skill bases within the agency, and reduces the likely benefits of outsourcing. It was also shown that clients who are willing to entertain acceptable risks can lead the industry in demonstrating the benefits of innovation. This 'entertainment of reasonable risk' is a best practice approach to risk. Unfortunately, the public sector is still dominated by a culture of risk aversion (Manley 2001). Indeed, the findings of Case C provide an example of a risk-averse client, which potentially created an impediment to innovation. In that case, consultants played a key role in allaying fears by educating the client. Yet, there remains a need for tailored programs across Australian public sector agencies to encourage greater risk-taking.

On a more positive note, Case A revealed that innovation can be prompted by clients who invite users to be involved in project scoping and management. User involvement tends to create pressure for minimisation of long-run operating costs and results in more functional buildings. The action of the client in this case responds to calls in the literature for client-led strategies to improve supply-chain integration (Briscoe et al 2004). Indeed, the findings here support the view that clients are 'key drivers of performance improvement and innovation and are the most significant factor in achieving integration in the supply chain' (Briscoe et al 2004, 193).

Case B illustrated other roles government clients can play in shaping the industry's innovation opportunities, through prequalification activities and contract types. Prequalification systems designed in part to measure innovation performance create a strong innovation driver, while the selection of contract types that involve as many parties as possible, as early as possible, lead to synergistic benefits and innovation. This last point is reinforced by the work of Ehrenkrantz (1998), which explores the links between procurement systems and innovation. Indeed, an emerging focus in the literature is the design of incentive systems within contracts to promote goal alignment between clients and construction industry participants, encouraging the flexibility that allows change and innovation (see Rose 2004 for a recent summary). This follows from the view that clients have a better chance of achieving their goals if they view their contractors and consultants as 'employees' and seek to motivate them accordingly (Turner 2004, 75).

Building regulators are also very instrumental in driving innovation through the supply chain. In Case C, it was shown that performance-based building codes encourage innovation, reinforcing the findings of Gann (1998), while in Case A, environmental standards were set just beyond current industry capabilities, creating a strong driver for innovation and efficiency gains. Nevertheless, the literature warns that regulators and standard setters need to have a good grasp of current industry capabilities so that they are able to effectively set regulations and standards at levels that are appropriate to encourage innovation (Gann 1998).

The case studies support findings in the UK 'that, in general, performance standards allow firms the freedom to innovate while prescriptive standards stifle creativity' (Gann 1998, 291). The same study concludes that 'clarity and simplicity is needed in the regulatory process to enable the uptake of good practice and encourage innovation. Failure to provide clear and enforceable rules is likely to have repercussions which damage industry's capacity to change, constraining future developments' (Gann 1998, 291).

Turning now to the role of technical support providers in driving innovation implementation, recall that international industry associations provided primary stimulus for the innovation in Case A, and university research played a central role in facilitating the innovation in Case B, while in Case C, the quality of the innovation was enhanced by international linkages with global experts. Further, the case studies indicate that technical support providers are particularly important when innovation relies on formal R&D. This is because the industry's structure and profit margins limit the extent to which other participants, such as contractors or consultants, can sustain formal R&D programs.

One of the important features of the knowledge base, which is managed by technical support providers, is the relative ease with which industry participants can access it. The case studies reviewed here show that industry networking with technical support providers still matters to competitiveness, however, the literature warns that this could be compromised by the increasing inaccessibility of public-sector science, with negative implications for national growth rates (Nelson 2004). This inaccessibility is associated with commercialisation trends and associated patenting activity by public sector research organisations, which limits the diffusion of knowledge.

Finally, the role of consultants is reviewed. In some ways this is saving the best for last. It is clear that in all three case studies consultants were active drivers of innovation that was in turn facilitated by client behaviour, changes to regulations and relationships with technical support providers. Indeed 'there is widespread consensus that design is becoming increasingly important in determining competitiveness' (Salter and Torbett 2003, 573).

Consultant activity is pivotal on construction projects. Engineers and architects are responsible for translating technical possibilities into objects that respond to client needs and market opportunities (Salter and Torbett 2003, 573). However, the interviews conducted for the case studies revealed consultants that were not merely responding to 'demand-pull' pressures, but were proactively engaged in 'science-push' type activities. The consultants appeared to have the strongest links to international knowledge bases, compared to the clients, contractors and suppliers examined.

These four classes of participants – clients, regulators, technical support providers and consultants – stand out in the current context from all the participants reviewed in Figure 1. The effectiveness of these participants in promoting innovation is mediated by the type of contract employed on the project. Contracts that promote goal alignment, flexibility and integration are more conducive to innovation. There is an extensive literature on this topic and interested readers are referred to Turner (2004) and Briscoe (2004). Here, the underlying driver is discussed – effective relationships.

The case studies reveal the extent to which relationships between participants drive innovation implementation, particularly international linkages. Indeed, the need for strong industry networking is emphasised in the literature, in view of the fragmented and temporary nature of production activities in construction (Slaughter 1998, Blayse and Manley in print). The importance of an organisation's ability to absorb external information has been emphasised since the early 1970s (Freeman et al 1972) and has only been highlighted by the rapidly increasing pace of change as we move into the 21st century (Neville 1998).

The relationships reviewed in the case studies centred on the need for knowledge. The importance of knowledge in learning economies is highlighted by the literature on innovation and growth, which is marked by the view that knowledge has become the most critical variable in productive activity (Marceau et al 1999, 2-9). In the construction industry, Green et al (2004, 72) found that poor communication is a key factor in constraining innovation rates. This finding is supported by the case work reported here, where successful innovation is linked to active inter-organisational and inter-sectoral relationships involving the communication of knowledge.

The case studies also show that the networking activity resulted largely in incremental innovation, rather than radical innovation. Incremental innovation is characterised by the adoption, refinement and enhancement of existing innovations. The study by Green et al (2004, 67) showed that the diffusion of existing innovations through incremental innovation was a key factor in construction industry growth, partly because of the impact incremental innovation has on cultural change. Incremental innovation involves an understanding of the need for continuous improvement, overturning the social norms in the industry that support complacency.

Yet, incremental innovation, like that demonstrated in the case studies, is typically problem-driven, reactive innovation. The lack of emphasis on more proactive innovation represents a relatively untapped source of industry growth. Incremental innovation helps in improving industry culture, however a 'blame-free' culture is even more important for proactive innovation and, as yet, opportunistic behaviour in the industry remains too dominant to allow this type of innovation to flourish.

The lack of emphasis on proactive innovation suggests fewer formalised R&D programs in organisations and hence less ability to access government programs that support R&D. Given this, a recent report suggests that programs supporting education and training initiatives can assist in promoting innovation rates. The same report argues that service industries, such as construction, need to be assisted in this way to match the support provided to manufacturing organisations through R&D programs (Thorburn and Langdale 2003, 38).

Overall, the experiences of innovators in the case studies emphasise the highly interactive nature of successful innovation implementation processes and the importance of robust business networking. Many construction industry participants are wary of sharing knowledge, reflecting a history of adversarial relationships. However, these case studies suggest that sharing knowledge pays. Cooperation is increasingly regarded as an essential component of self-interested growth. As the literature notes, 'knowledge sharing is not a zero sum game' (Green et al 2004, 12).

There are clear opportunities for further research. Indeed, in related studies, the authors are applying a similar perspective to a study of the Australian road and bridge industry, and are also undertaking a large-scale quantitative study of interactive innovation implementation processes in the Australian B&C industry. A number of specific issues raised in the present study warrant more attention and these include the relative merits of reactive and proactive innovation, and the policy implications of the relative inability of many construction organisations to conduct internal R&D compared to manufacturing organisations.

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